CIRCULAR 6151 JULY, 1929

RECEIVED
SEP - 3 1929
. LIBRARY

INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE - BUREAU OF MINES

METHOD AND COST OF MINING THE UPPER AND LOWER FREEPORTS AND THE LOWER KITTANNING COAL IN A GROUP OF MINES IN WESTERN CENTRAL PENNSYLVANIA

BY

J. W. PAUL AND H. TOMLINSON

Circular 6151
July, 1929.

INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE - BUREAU OF MINES

METHOD AND COST OF MINING THE UPPER AND LOWER FREEPORTS AND THE LOWER KITTANNING COAL IN A GROUP OF MINES IN WESTERN CENTRAL PENNSYLVANIA [1]

By J. W. Paul[2] and H. Tomlinson[3]

This circular is one of a series of reports on coal mining methods and costs which are being prepared by the U. S. Bureau of Mines for the purpose of making available to those interested in the industry a knowledge of the mining methods employed in mines where mechanical and hand loading is practiced and the cost data on the several operations pertaining to the removal of coal from the working faces and its transportation to the tipple for loading into railroad cars.

The methods employed are influenced by the natural local conditions with respect to the thickness and character of the coal beds and the overlying strata, the means employed for roof support and its control, and the disadvantages incident to the development of mines in thin coal beds.

Mining costs are governed to a great extent by the selection of the mining methods best adapted to the natural physical conditions of the property.

This paper presents a detailed description of the mining methods employed, the equipment used, and the results obtained in the operation of five mines working the thin coal beds in western Pennsylvania. The product is supplied to the open markets for domestic, commercial, and railroad fuel purposes.

ACKNOWLEDGMENTS

Through the courtesy of the president and the cooperation of the officials of the company operating the mines discussed, the details given herein have been made possible. This circular is printed with the approval of the executive official, who has checked the accuracy of the methods and data given.

---

[1] The Bureau of Mines will welcome reprinting of this article, but requests that the following footnote acknowledgment be used: "Printed by permission of the Director, U. S. Bureau of Mines. (Not subject to copyright.)"

[2] Senior mining engineer, U. S. Bureau of Mines.

[3] Associate mining engineer, U. S. Bureau of Mines.

HISTORICAL

The five mine plants described in this paper were opened and put into operation between 1910 and 1926, since which date 12,961,450 tons of coal have been produced up to and including 1928.

The Upper and Lower Freeports and the Lower Kittanning coal beds which are being mined at these properties have been mined for 50 years by numerous small or wagon mines in this district. The nature and quality of the coal, therefore, was well known prior to the development of this group of commercial mines.

GEOLOGY AND TOPOGRAPHY

A typical section of the geological measures is shown in Figure 1.

The coal beds worked are members of the Allegheny group of the Carboniferous Age, of which the Upper Freeport coal bed is the top member and lies 59 feet above the Lower Freeport and 218 feet above the Lower Kittanning in the district in which these mines are located. The overburden involving roof-control problems in the Upper and Lower Freeport beds is composed chiefly of members of the Conemaugh group, which consists of shales, sandstones, and limestones; the outstanding member of this group is the Mahoning sandstone which is 40 feet thick and lies 15 feet above the Upper Freeport coal bed. The roof-control problems of the Lower Kittanning bed are chiefly induced by the strata forming the Allegheny group which is composed of several thick beds of shale and sandstone an thin beds of limestone with several thin coal beds. This group of mines constitutes five surface plants, each of which is provided with tipple facilities

The elevation at the various mines is between 800 and 1,400 feet A.T. The topography of the district is decidedly hilly; small narrow valleys offer access to the coal beds by drifts.

CHARACTER OF COAL BEDS AND OVERBURDEN

Figure 2 shows detailed sections of the coal beds worked at the various mines.

The Upper Freeport bed, which is being mined at plants No. 1, 3, 4, and 5 varies from 35 1/2 inches in thickness at No. 4 to 46 1/2 inches in thickness at No. 3. At No. 1 plant it is 40 inches thick and has no binders or partings. At No. 3 plant it has a number of partings, and in ascending order consists of coal 22 inches, sulphur band 1/2 inch, coal 12 inches, sulphur 1/2 inch, coal 6 inche shale 1 1/2 inches, coal 4 inches.

At No. 4 plant the Upper Freeport bed is 35 1/2 inches thick with a band of sulphur 1/2 inch thick 15 inches from the bottom.

At No. 5 plant the bed worked is 36 1/2 inches thick, made up as follows in ascending order: 3 inches of coal on the bottom, 1 1/2 inches of shale binde 13 inches of coal, 1 inch of shale binder, and 18 inches of coal; over this bed is a sandstone roof.

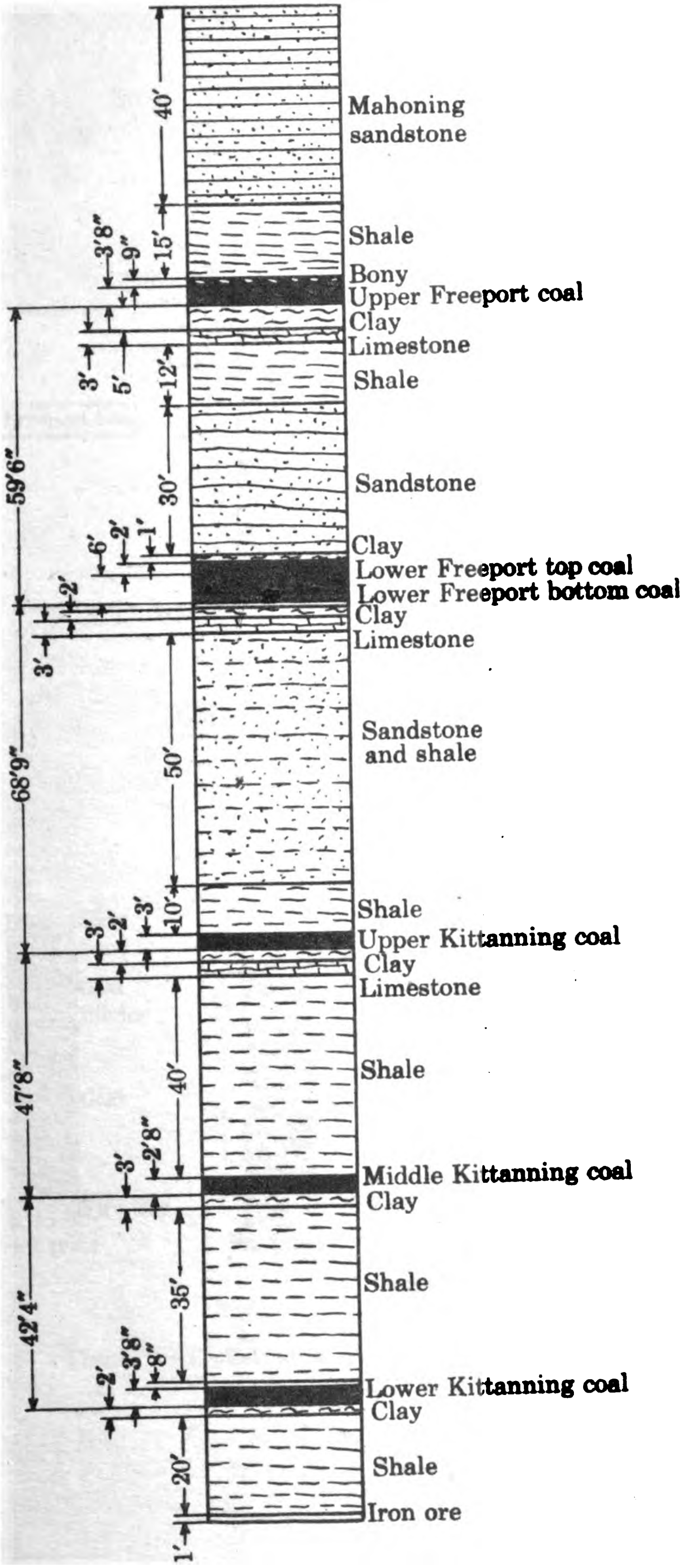

Figure 1.– Generalized geological section in central Pennsylvania district

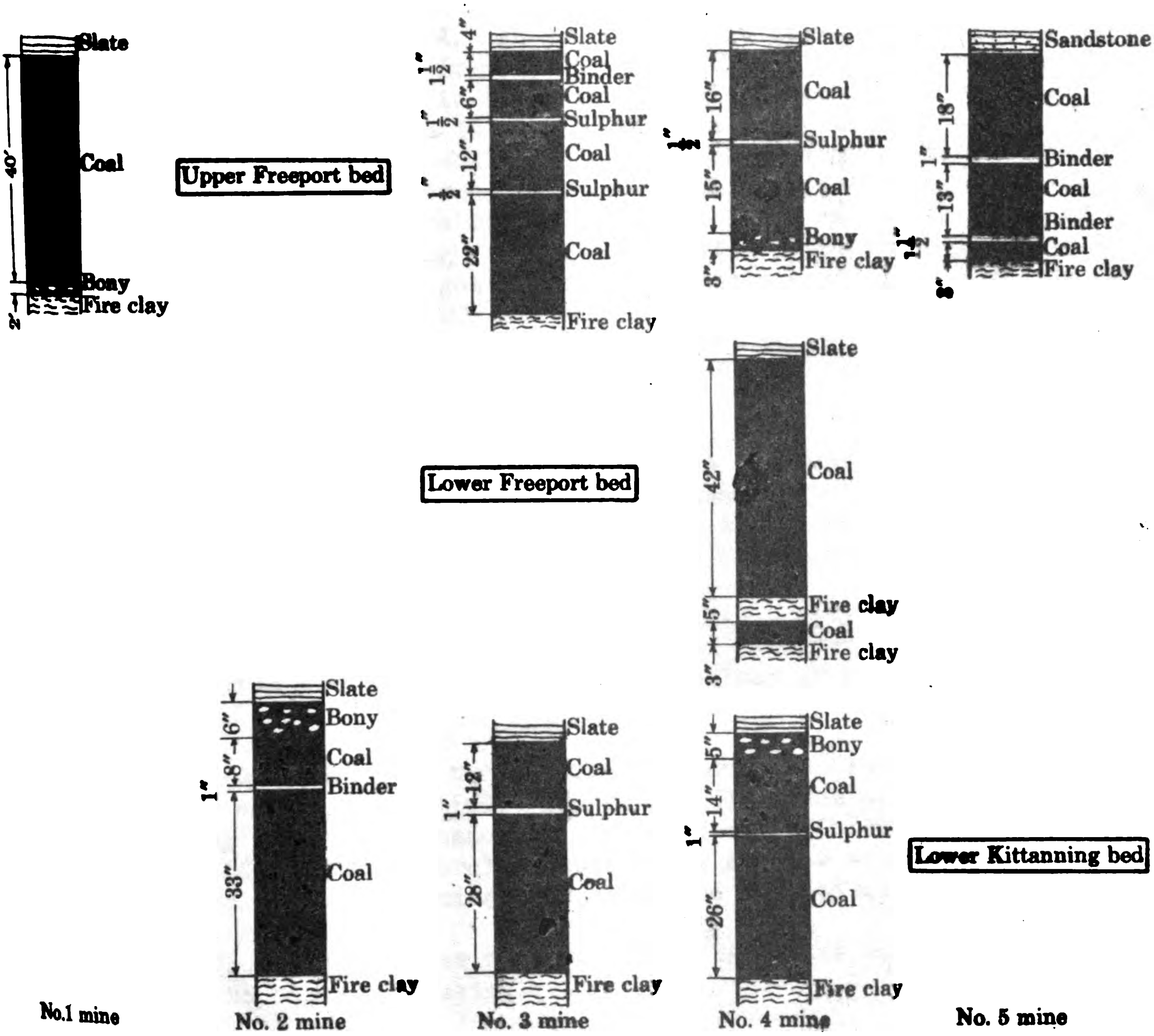

Figure 2.– Typical cross sections of the coal beds mined at five mines

The Lower Freeport coal bed is mined only at the No. 4 plant where it is 50 inches thick and divided by a bed of fire clay 5 inches thick 3 inches from the bottom. This bed is irregular in this district and is workable only in a few places.

The Lower Kittanning coal bed is the most uniform of the three beds and is being mined at plants No. 2, 3, and 4. At No. 2 plant it is 42 inches thick, and has a 1-inch shale binder 33 inches from the bottom with a 6 inch bed of bony on the top of the bed. At No. 3 plant it is 41 inches thick, with a 1-inch shale binder 28 inches from the bottom and is overlaid with a black slate roof. At No. 4 plant it is 41 inches thick, with a shale binder 26 inches from the bottom and a 3 inch bed of bony on the top. Numerous sulphur streaks are found in this bed, usually near the bottom and above the binder, which at times makes the drilling for shot holes difficult due to its being irregular. Sometimes several holes have to be started before it is possible to get one in the desired position. The face slips of the coal beds run about N. 20° E. While these beds are present in the same geological section of the rock measures, at present no two beds are operated superimposed, hence the mining in one bed has no effect on the workings in an overlying bed.

Immediate Roof.- The immediate roof of the Upper Freeport is a gray shale varying in thickness from a few inches to 15 feet, with an average thickness of about 10 feet. Above this gray shale is the Mahoning sandstone, the breaking and control of which forms the problem in pillar and long-face operations.

The immediate roof of the Lower Freeport coal is a gray sandy shale at some places 20 feet thick, and above which is a bed of sandstone about 30 feet thick. The roof measures give rise to no special problems in pillaring or in long-face work.

A black shale 20 to 40 feet thick forms the immediate roof of the Lower Kittanning bed and is easily controlled. However, small areas are found where a gray sandstone ranging from a few inches to several feet in thickness is found which makes a roof difficult to control. These areas are few and do not have a great influence in the choice of mining methods or the cost of mining.

Floor.- The floor under these coal beds is a hard fire clay from 3 to 5 feet thick and shows no signs of heaving.

Cover.- The cover over the coal beds varies from a few feet at the entrance of the mines to 400 feet under the highest points of the hills, with an average thickness of approximately 125 feet over the operations.

Faults and Dip.- There are no displacement faults in the coal, but frequent rolls are encountered where the grade on the haulage entries will be 5 per cent for short distances and then graduate to normal, which is approximately 2 per cent to the southeast.

Water.- The mines may be termed dry; the little water encountered is in the local depressions, from which it is removed by a small gathering pump. The water, however, has an acid reaction.

Gas.- Due to the light cover and outcrop workings no gas pressure has been encountered in any of these mines. On the property numerous gas wells have been drilled to a gas sand approximately 1,000 feet below the Lower Kittanning bed. These wells have been located and sealed by a special method adopted by this company.

PROSPECTING, EXPLORATION, AND SAMPLING

The property was well prospected by a number of small mines operated at intervals for 50 years previous to the opening of these mines. The quality of the coal, therefore, was well known. Since acquiring the 30,000 acres on which the company has mining rights, 551 diamond and churn drill holes have been put through the coal measures, the findings of which have checked well with the present workings. Average analyses of the various coal beds are as follows:

	Per cent
Moisture	1
Volatile matter	34-37
Fixed carbon	52-56
Ash	6-10
Sulphur	1¼-3

METHODS OF DEVELOPMENT AND MINING

The coal beds which crop out on the hillsides are being worked by drifts. Electric locomotives deliver the coal from the mine workings to the tipple; in some instances a long surface haulage is necessary.

Tipple.- The tipples and preparation plants are of steel and wood construction with corrugated steel siding. They are equipped with screens and picking tables for sizing and cleaning the coal for domestic, commercial, and railroad fu

Method of Mining.- The general plan of development has been on the room-and-pillar panel method (fig. 3). Four entries are driven in from the surface 10 feet wide and 6 feet 6 inches high on 50-foot centers with a barrier pillar of 75 feet on either side. From these entries at intervals of 2,000 feet, four face entries are turned at right angles on each side on 50-foot centers with a 75-foot barrier pillar for protection. From the face entries at intervals of 550 feet, pairs of butt entries are turned on 50-foot centers and driven through to the ne face entries, from which rooms 30 feet wide on 50-foot centers are turned on both sides as the entries advance. Room necks are 10 feet wide and 16 feet long. The rooms are 250 feet long and are holed-through to the corresponding room on the next butt entry. When the rooms are driven the desired length, the pillar is immediately withdrawn by making cut-throughs 20 to 24 feet wide, leaving for

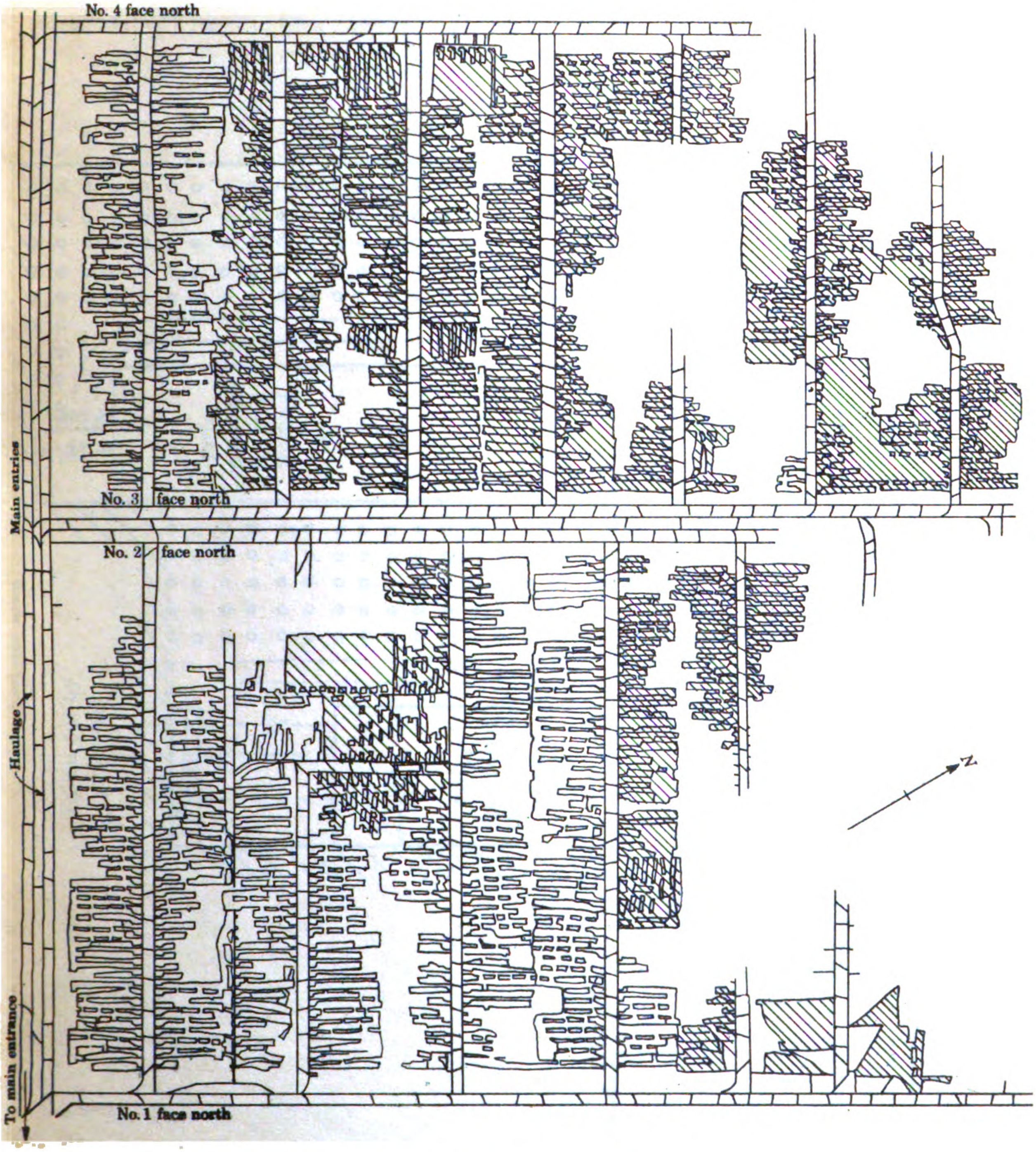

Figure 3.– Typical development of the mines

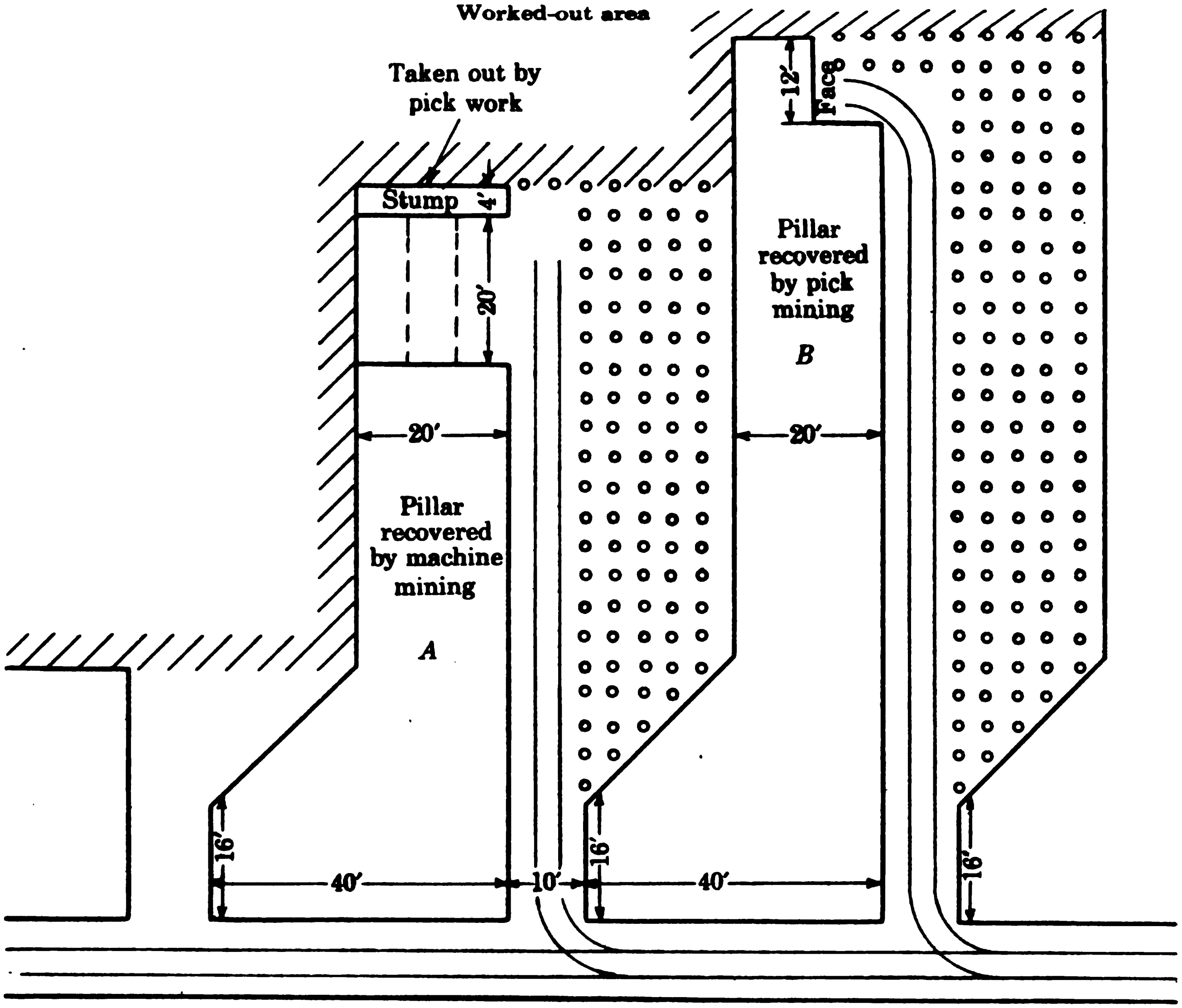

Figure 4.– Sequence of operations in removing room pillars

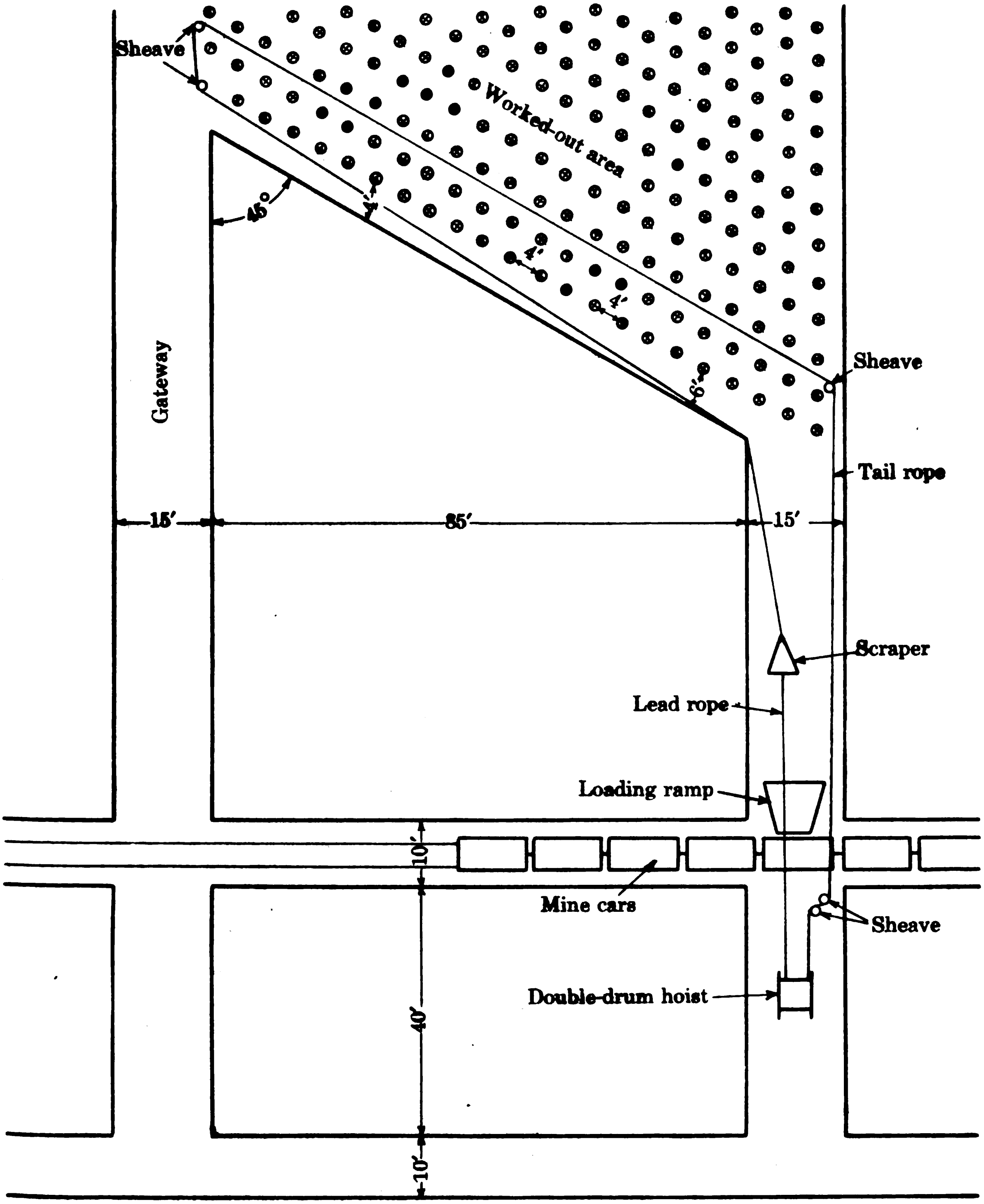

Figure 5.– Saw-tooth method of mining, using scraper loader

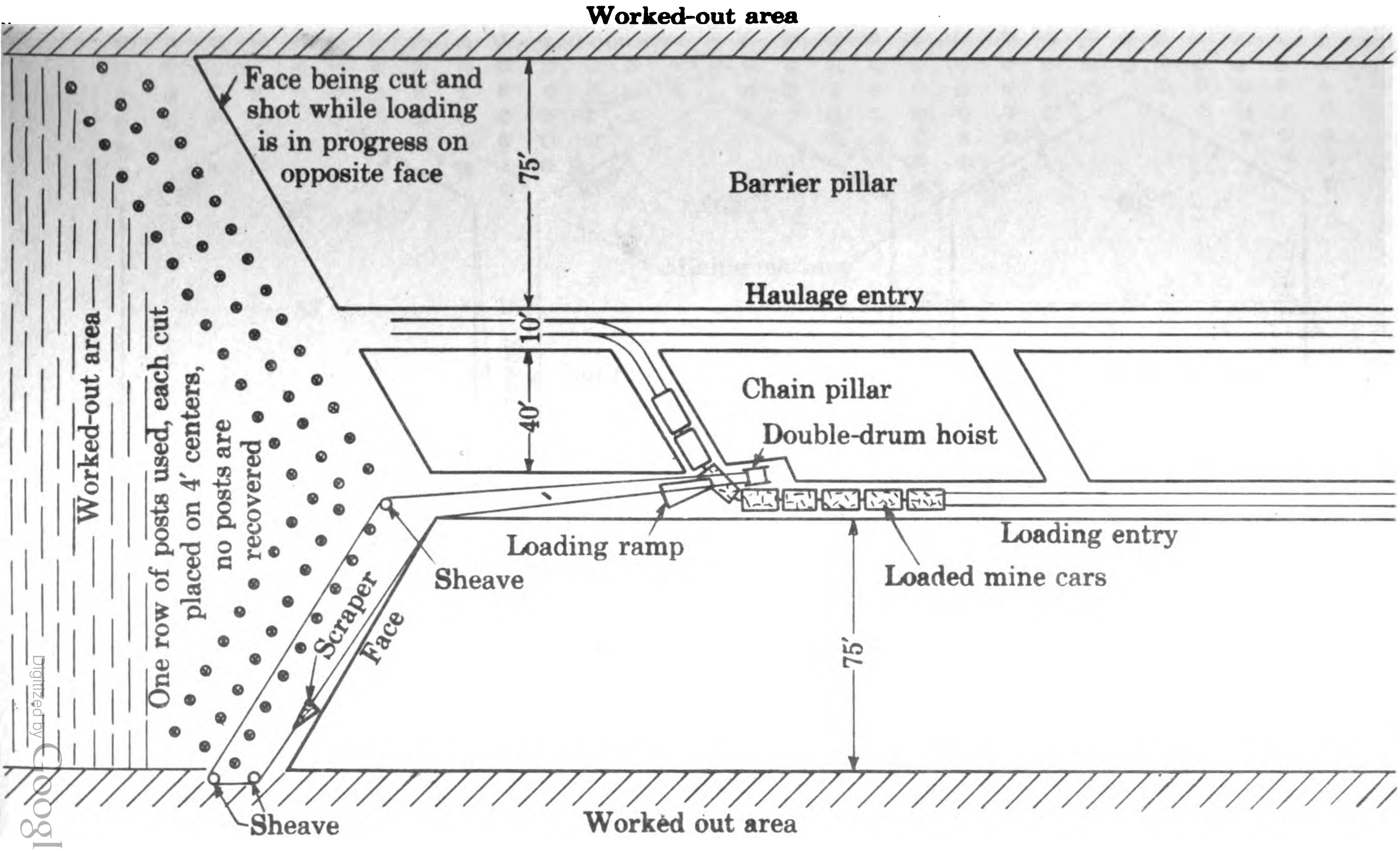

Figure 6.– Saw-tooth method of mining with scraper loader in removal of entry chain and barrier pillars

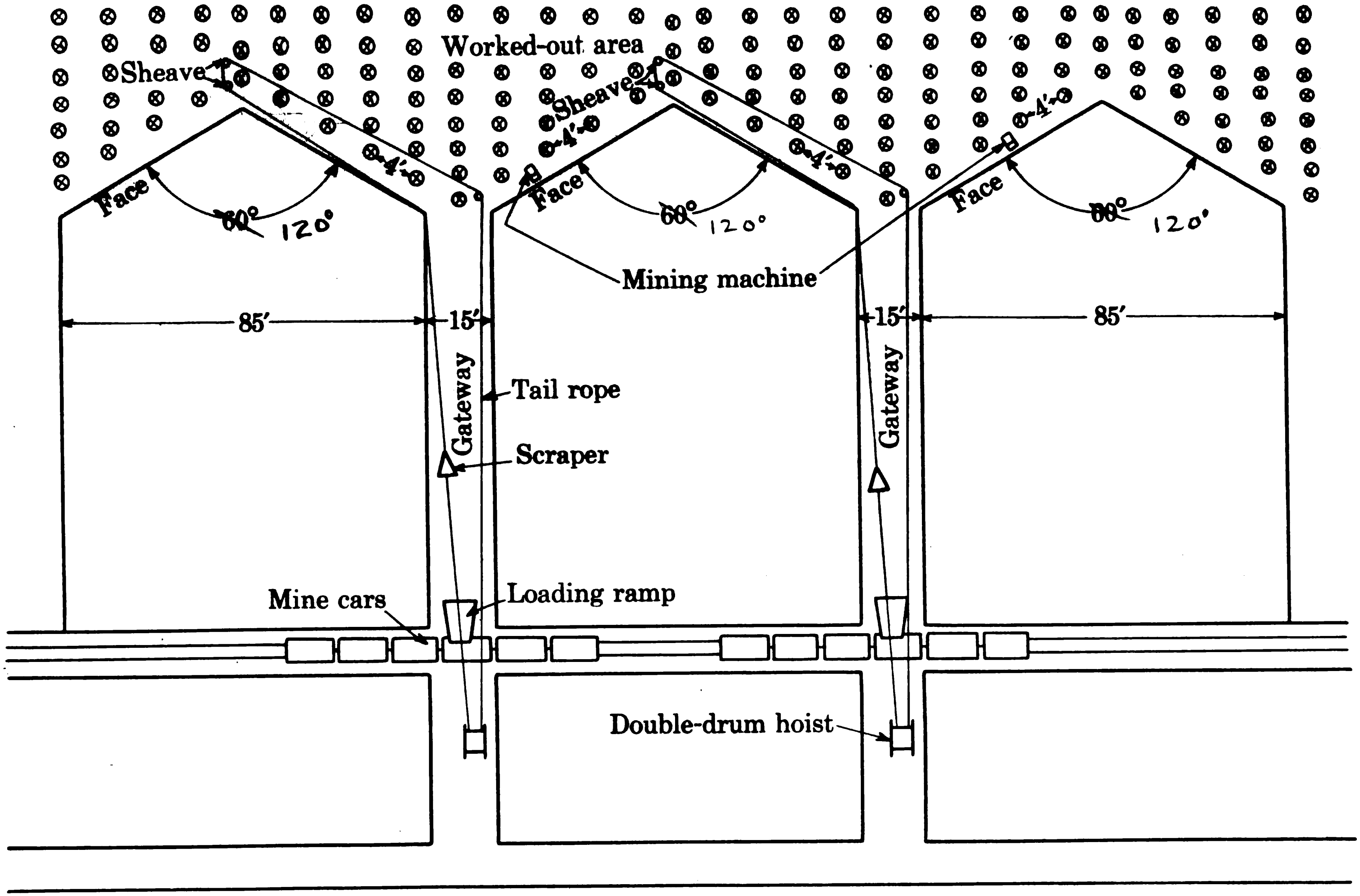

Figure 7.– V-face method of mining with scraper loader, equal faces

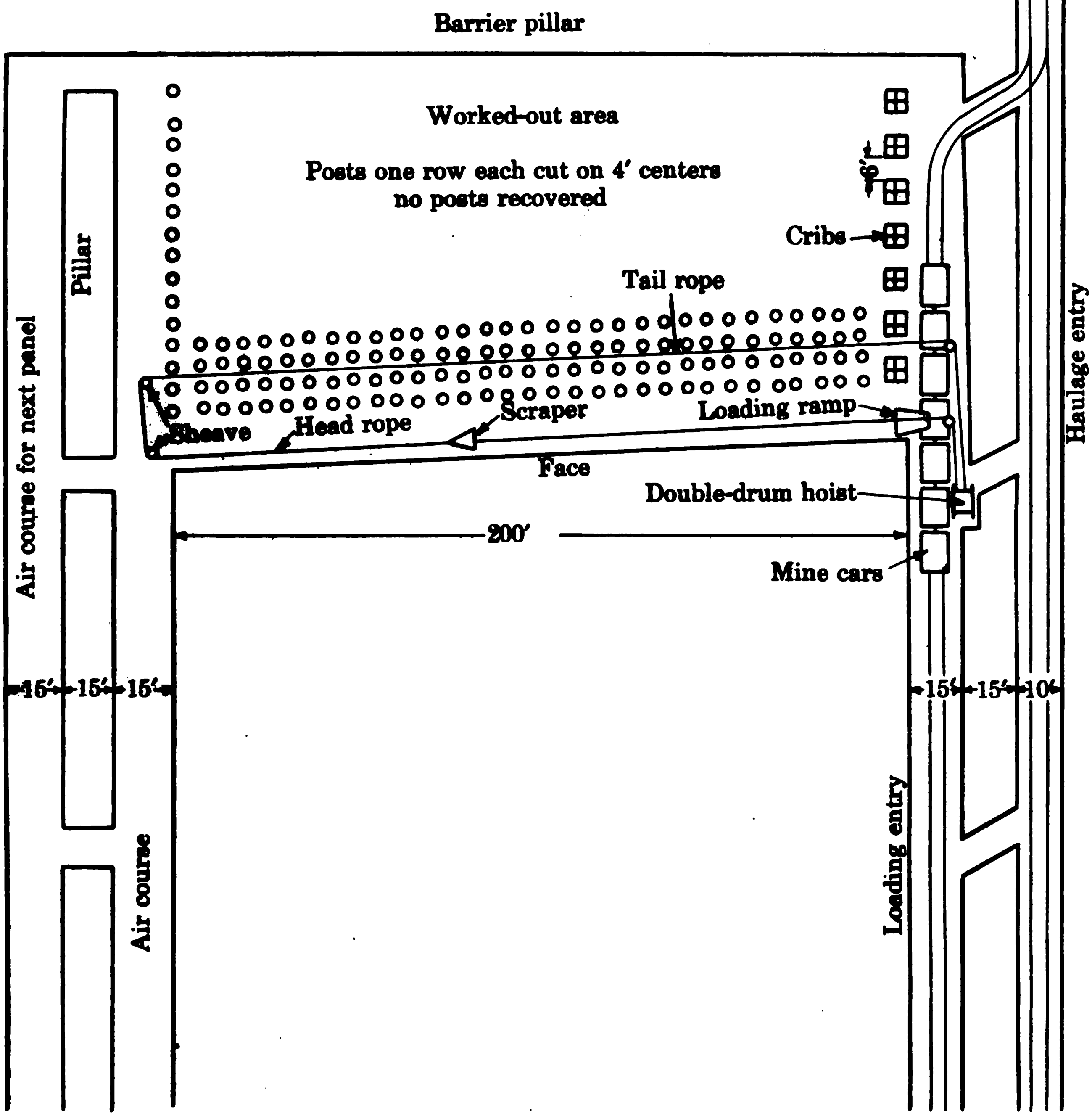

Figure 8.— ~~Longwall~~ mining with scraper loader

Long face

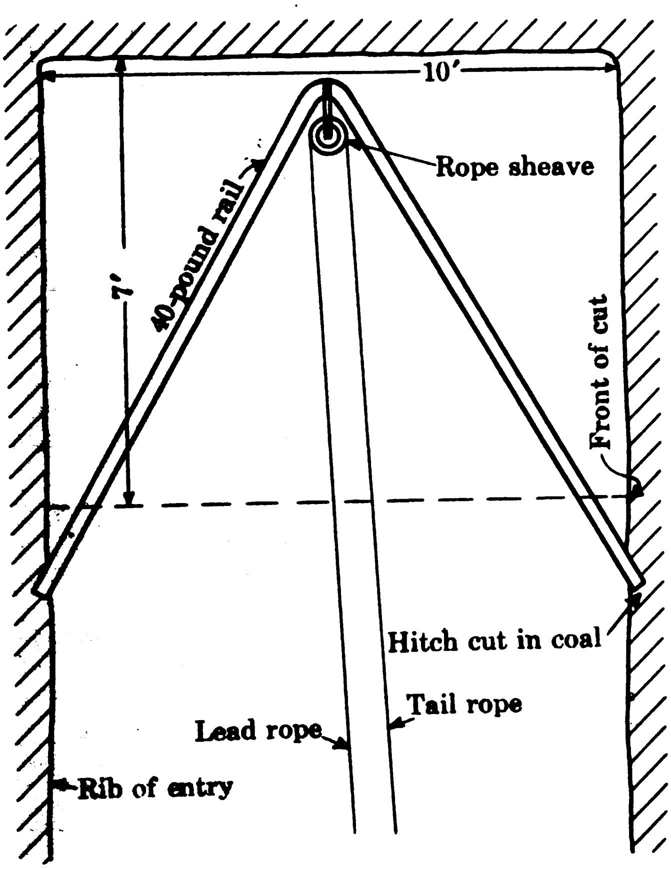

Figure 9.– Position of anchor for rope sheave at face of entry

protection a stump 4 to 6 feet wide, which is taken out by pick work as shown in Figure 4. Owing to the easy manner with which the roof is controlled, no effort is made to carry a uniform breakline; several pillars often are taken out without the occurrence of a roof fall.

In the saw-tooth method the gateways are driven 100 feet apart and are 15 feet wide and 250 feet long; a face is then made at an angle of 30 to 45° and connected with the next gateway. This block is then loaded out by means of a scraper, which pulls the coal to the loading point on the entry as shown in Figure 5. This method is being worked successfully. The saw-tooth method is used in the removal of the entry chain and barrier pillars as shown in Figure 6.

In the V-face method (fig. 7), the gateways are driven the same as in the saw-tooth method, then two faces are made at angles of 45° with the gateway and connected with faces in the next gateway. The faces have the shape of an inverted V on the solid block of coal to be worked back to the entry; these faces are about 60 feet long on either side of the gateway. While the coal is being loaded out by the scraper loader on one side, the other face is being cut and blasted so as to have a continuous loading operation during the shift. This method is being abandoned because of the difficulty encountered in ventilating the faces when a fall occurs.

In the longwall block method, gateways are driven 200 feet apart; a face is then made by connecting the two gateways, and the block of coal is taken out by retreating towards the entry, as shown in Figure 8.

The gateways for mechanical loading are driven by the aid of a scraper loader. An anchor for the rope sheave is used at the face of the entry, and both anchor and sheave are placed in the kerf before the coal is blasted (fig. 9). To get the scraper into the coal by this means, a part of the coal shot down must be first shoveled into the scraper.

Mining.- All the coal except the small stumps left for protection in the room pillars is mined by electrically driven machines of the shortwall type. There are 66 of these machines equipped with 6 1/2-foot cutter bars at the five mines.

The following table shows the number of mining machines at each plant and the average daily tonnage produced per machine:

Number of mining machines at each plant and average daily tonnage produced per machine

Plant	Total tonnage	Days worked	Average daily tonnage	No. machines employed	Daily tonnage per machine
1	190,969	168	1136.7	12	94.725
2	179,946	176	1022.4	12	85.2
3	244,337	173	1412.3	15	94.155
4	281,567	190	1481.9	23	64.43
5	33,396	166	201.2	4	50.3

Drilling and Blasting.- The shot holes for breaking down the coal are drilled by the miner with post augers in the hand-loading sections, and by one of the crew, using an electric drill, in the mechanical-loading sections. The augers are 1 3/4 inches in diameter, and the holes are drilled 4 to 6 inches shorter than the mining. In the rooms and entries three shot holes are placed as indicated in Figure 10. In the rooms (figs. 10-A, B) two rib shots are placed about 9 inches from the roof and 1 foot from the rib, and the center or breaking-in shot hole is placed near the center of the face and about 9 inches from the roof. All these shot holes are inclined so as to hit the roof at the end of the hole, on account of the tendency of the coal to stick to the roof. The center shot is fired first, using 2 to 2 1/2 sticks of pellet powder or 1 1/2 to 2 sticks of permissible explosive. After the coal from the center shot is loaded out, the rib shots are fired, using 1 to 2 1/2 sticks of pellet powder or permissible explosive.

In the long faces where the coal is loaded mechanically, the shot holes are spaced 6 feet apart, alternately placing them in the center of the bed and 9 inches from the roof, as indicated in Figure 10-C. One to two sticks of explosive are used in these holes according to the work to be accomplished. The shot holes are all tamped with clay and fired electrically by the miners.

The preparation of a good-sized clean product has had to be given major consideration at these plants which are working in thin beds where streaks of sulphur and binders occur. Since mechanical loading has been the practice, no considerable improvement has been noticeable either in size of product or in freedom from impurities over the hand-loading methods, and this fact is due to the thought and consideration being given to the proper blasting of the coal.

During 1928, 186,043 pounds of pellet blasting powder and permissible explosive were used to produce 930,215 tons of coal, thus showing that 5 tons of coal were produced per pound of explosive.

Rooms and Pillars.- Rooms 30 feet wide are developed by advancing on the face cleats of the coal. No floor or roof is taken down for increased height either in rooms or pillars. As shown in Figure 4-A, the pillars or ribs are withdrawn by making cuts 20 to 24 feet wide in the rib, leaving a stump 4 to 6 feet next to the gob for protection. The ribs are 20 feet thick. When the cut-throug is made, the stump is then removed by pick work. This sequence is carried out until the room neck is reached. In places where the ribs are recovered by hand mining, no stump is left, and the pillar is worked off in 12-foot blocks on the e This is known as the open-end method, as shown in Figure 4-B.

Entries.- Entries 10 feet wide are advanced on the face or butt slips, a a scraper loader is used for the loading. The scraper hoist is set up in the la breakthrough so that the cars can pass through the breakthrough to the loading point. The work is concentrated on one entry until it reaches the required distance for another breakthrough, and then the operations are transferred to the other entry; while 3 feet of roof is being taken down for head room by a crew of four men, four cuts, or 24 feet of advance a shift, are made in an entry. The crew is paid on a tonnage basis.

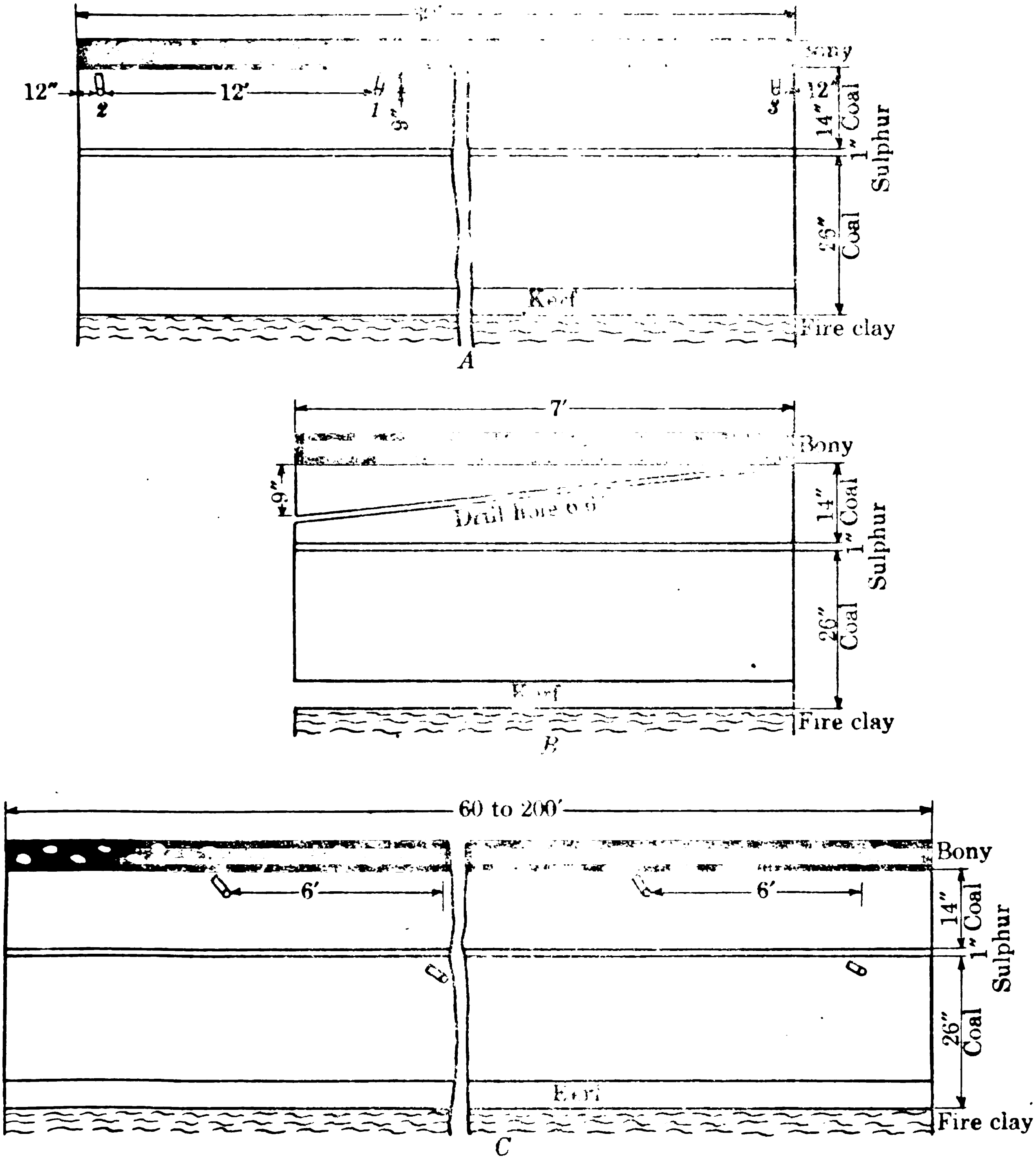

Figure 10.— Position of shot holes. A and B, Rooms 30 feet wide; C, faces 60 to 200 feet long

In the recovery of the entry pillars a V-face is made, and a scraper loader is used (fig. 6). This work has been very successful, insomuch as a better recovery of the coal has been made at a lower cost.

Loading.- During 1928, 173,375 tons of coal, or approximately 23.5 per cent of the coal produced in four of the five mines under consideration, were loaded mechanically. This may be termed an experimental period. Six men formed a crew and cut, blasted, and loaded from 80 to 130 tons per shift on contract work, paid on a tonnage basis. During this same period 756,840 tons were hand-loaded and paid for on a tonnage rate.

The following table gives the number of tons hand and mechanically loaded during the year 1928:

Tonnage loaded mechanically and by hand during 1928

Mine	Total tonnage	Tons hand-loaded	Tons mechanically loaded	No. mechanical loaders employed	Percentage of coal hand-loaded	Percentage of coal mechanically loaded
1	190,969	190,969	- -	-	100.00	- -
2	179,946	141,251	38,695	4	78.50	21.50
3	244,337	200,439	43,898	6	82.00	18.00
4	281,567	212,883	68,686	8	75.61	24.39
5	33,396	11,300	22,096	4	33.84	66.16

Deadwork.- The two principal items under the heading of deadwork are the additional compensation paid for narrow work, and the necessity of taking down 3 feet of roof for headroom in all entries and air courses. This work is performed by the miners and is paid for on a yardage basis converted to the tonnage rates. Extra compensation in addition to the tonnage rate is also paid where the miner handles the cars to and from the butt entry to the room or pillar face.

The items of deadwork necessary for the miner to perform and which are included in the mining or loading rate are drilling, blasting, and cleaning the coal of sulphur streaks, binders, and other impurities, which is the general practice. This also involves the care of the roof and its support in working places, and the laying of track, except the curves and switches.

Timbering.- The immediate roof consists of shale several feet thick and forms a good roof over the several mines. Where roof support is necessary on the haulageways it is furnished by 6 by 8-inch square timber, but in the five mines little roof support is necessary on the entries or haulageways.

A definite system of roof support has been adopted for rooms, pillars, and long faces, as shown in Figures 4, 8, and 11. In rooms 30 feet wide, five rows of posts are used; the first row is placed 10 feet from the rib on the track side, then, spaced 4 feet apart and on 4-foot centers, are carried to within 6 feet of the face before blasting, as shown in Figure 11. In the pillars two rows are carried, one on either side of the track and on 4-foot centers. In the long faces one row of posts is used, each cut placed on 4-foot centers. Where a local bad roof condition is encountered, additional posts are placed to the best advantage.

Good cap pieces of varied sizes are used on all posts, and the posts are a good quality and not less than 4 inches in diameter.

During 1928 the timber used for roof support at the various mines was as follows:

Timber used for roof support at the various mines

Mine	Tonnage	No. posts	Length	Entry support legs and cross-bars 6"x8"x9'	Tons per post	Total linear feet	Tons pe linear foot
1	190,969	38,193	3 ft. 8 in.	100	5.00	140,941	1.35
2	179,946	35,950	4 ft.	240	5.00	145,960	1.23
3	244,337	48,860	4 ft.	50	5.00	195,890	1.25
4	281,567	70,392	3 ft. 3 in.	175	4.00	230,350	1.22
5	33,396	6,670	3 ft. 3 in.	-	5.00	21,677	1.08

Haulage.- Mine tracks, size of trip, and equipment have been standardized. A track gauge of 42 inches is used. The standard radii of curves and switches are 70 feet for a No. 3 frog on main haulage, and 17 feet for a No. 1 1/2 frog on room turnouts curves.

Rails are 75 and 40 pounds on the main haulageways, 30 pounds on the butt entries, and 16 pounds in rooms. Ties 5 inches by 6 inches spaced on 2-foot centers are used on the main haul and butt entries, while steel ties are used in rooms. The tracks are kept clean, well graded, and on the center line of the entries, thus insuring good haulage.

The cars are delivered to the room necks by gathering locomotives where hand-loading is the practice. From this point they are taken to and from the face by the miner, who is paid extra compensation for this work.

Where mechanical loaders are used, the cars are delivered to the loader i trips of 12 cars; as the cars are loaded they are moved away from the loader by a small hoist set up for that purpose, and so arranged that when the locomotive arrives with a trip of empties there is an equal number of loads to be taken away.

At the several mines there are 45 locomotives in operation on the various haulage systems. The following table shows the number and size of the locomotive at the various mines with the average number of tons hauled daily per locomotive during 1928:

Number, size, and average daily haulage of locomotives at the various mines

Mine	No. of locomotives	20-ton	15-ton	8-ton	Gathering 3 1/2 ton	Average daily tonnage per locomotive
1	8	-	-	8	-	142.9
2	12	-	1	6	5	85.2
3	10	1	-	6	3	117.7
4	13	-	-	10	3	114.8
5	2	-	-	-	2	100.6

The 20-ton locomotive at No. 3 mine, the 15-ton at No. 2, and some of the 8-ton locomotives at Nos. 1, 2, 3, and 4 are used as main-haul locomotives; the others are used on butt and face entries, while at No. 5 mine the 3 1/2-ton locomotives deliver their trips to the outside.

Owing to the reorganization of the haulage system incident to changes in methods of mining, an exhaustive study of the haulage methods in use at these mines was not made.

In addition to the coal hauled by the locomotives, an average of 100 to 150 cars of refuse were hauled daily during the year at the four larger mines.

Mine cars.- The following table gives the number and capacity of the mine cars at each plant.

Number and size of mine cars used at the various mines

Mine	Wooden cars, 1 1/2-ton capacity	Steel cars, 2 1/2-ton capacity	Steel cars, 3 1/2-ton capacity	Total
1	600	-	-	600
2	325	-	-	325
3	200	200	100	500
4	750	-	-	750
5	60	-	-	60

Wooden mine cars of 1 1/2-ton capacity with end gates and solid bearings heretofore have been the standard, but with the introduction of mechanical loading the necessity for a larger mine car was seen; a steel car of 2 1/2 and 3 1/2 ton capacity is now being furnished, equipped with brakes and Timken bearings.

Ventilation.- The ventilation is supplied at the various mines by electrically driven fans. The following table shows the type of fan used, quantity of air delivered, and the water gauge in inches:

Ventilation at the various mines

Plant	Bed and type of fan	Water gauge, inches	Quantity of air per minute	Total quantity of air
1	U. F. (8 ft. Sirocco	1-1/2	200,000	
	(6 ft. Disc	1	45,000	
	(6 ft. Disc	1	45,000	290,000
2	L. K. (8 ft. Jeffrey	1-1/2	200,000	
	(6 ft. Disc	1	45,000	245,000
3	L. K. 8 ft. Jeffrey	1-1/2	200,000	
	U. F. (6 ft. Disc	1	45,000	
	(6 ft. Disc	1	45,000	290,000
4	L. K. 7 ft. Robinson	2	300,000	
	L. F. 8 ft. Jeffrey	1-1/2	200,000	
	U. F. 8 ft. Disc	1	90,000	590,000
5	U. F. 6 ft. Disc	1	45,000	45,000

There is a good supply of air at the working faces.

Blower fans with flexible tubing are used to force the air to the face while driving the gateways in the mechanical loading sections. The chief disadvantage in the V-face operations, which are now being abandoned, was the difficulty encountered in ventilating the faces after a fall of roof.

Stoppings are constructed of coal, slack, and cement, and some are made of brick laid up in mortar. Overcasts have been constructed with brick side walls and brick laid on the flanges of T-rails for the tops. Doors are constructed of 1 by 12 inch lumber doubled and hung to close with the air current.

Power and Voltage.- Purchased power is furnished to the several mines in 2,300 volts a.c. units, where it is converted into 250 volts d.c., which is the voltage used on all underground electrical equipment.

The following power was consumed at the various mines during the year 192

Power consumed at the various mines, 1928

Mine	Kilowatt-hours consumed	Tons produced	Kilowatt-hours per ton produced
1	1,231,580	190,969	6.449
2	1,628,900	179,946	9.052
3	2,096,935	244,337	8.582
4	2,564,810	231,567	9.109
5	226,100	33,396	6.770

Contract and Bonus Wage Systems.- The "November, 1917, scale of wages" is being paid all employees. The miners are paid on a per-ton basis, plus a yardage rate for narrow work and brushing roof for headroom, as discussed under "Deadwork." He supplies the explosives required for blasting coal and roof, which is purchased from the company at cost. Cutters are paid on a tonnage basis. Day men are paid at a daily rate, 8 hours constituting a day's work. Supervising officials are paid on a monthly basis. Some contracts are let to crews of men in the mechanical-loading sections. In these cases the crew consists of from four to seven men who cut, blast, timber, and scrape the coal into the mine cars and do all the work incidental to delivering the coal from the face into the mine cars on a tonnage basis.

No bonus system is in vogue at these properties; a plentiful supply of good labor is available.

Percentage of Coal Recovered.- It is estimated that 90 per cent of the coal is recovered under the room-and-pillar method of working and 98 per cent in the long-face or mechanical-loading sections.

SUMMARY OF COSTS AT FIVE MINES IN CENTRAL PENNSYLVANIA

Tons Mined and Hoisted During Period.- During the year 1928, 930,215 tons of coal were produced, 173,375 tons of which were loaded mechanically and 756,840 tons were hand loaded.

Mining Method.- The mining methods employed were the room-and-pillar, saw-tooth, V-face, and long-face panel method.

Mining costs per ton expressed in percentages

	Labor	Material	Total
Mining	46.27	5.5	51.77
Deadwork	3.01	2.16	5.17
Timbering	.17	.02	.19
Ventilation	.24	.34	.58
Transportation	9.3	2.15	11.45
Tipple	3.3	.93	4.23
Power	.62	9.3	9.92
Pumping	.64	4.3	4.94
General mine expense	7.85	3.9	11.75
Total	71.40	28.60	100.00

Mining, Labor, and Material.- Mining, labor, and material include cost of cutting, blasting, hand and mechanical loading, maintenance of and materials for mining machines and mechanical loading equipment, and maintenance of rooms.

Deadwork and Material.- Labor and material cost of yardage paid as compensation for narrow work in entries, air courses, crosscuts, and taking down roof for headroom.

Timbering and Material.- Labor and material cost of timbering, entries, and air courses performed by day men, and posts furnished for roof support in rooms, pillars, and long-faces.

Ventilation and Material.- Labor and material cost of operation and maintenance of ventilating equipment, construction of brattices, stoppings, doors, and overcasts.

Transportation and Material.- Labor and material cost of operating of locomotives, maintenance of haulage roads, track work, car pushing, general haulage and car repairing.

Tipple and Material.- Labor and material cost of operation and maintenance of tipples and preparation plants.

Power and Material.- Labor and material cost of operation, maintenance of substations, transmission lines, and purchase of power.

Pumping and Material.- Labor and material cost of operation and maintenance of pumps and drainage ditches.

General Mine Expense and Material.- Includes superintendence, engineering, clerical force, watchmen, policemen, miners' compensation, insurance and liability and supplies.

Units of Labor.- The following table shows the total tonnage produced at each mine for the year 1928, the number of days worked and men employed, the daily average tonnage at each mine, and the number of tons per man employed daily; also the total man hours worked and tons produced per man-hour unit:

Work performed at the various mines, 1928

Mine	Total tonnage	Men employed	Days worked	Daily mine tonnage	Tons per man employed	Total man hours	Tons pe man hou
1	190,969	200	168	1,136.7	5.68	268,800	.7104
2	179,946	176	176	1,022.4	5.81	247,808	.7261
3	244,337	207	173	1,412.3	6.82	286,488	.8528
4	281,567	268	190	1,481.9	5.53	407,360	.6912
5	33,396	33	166	201.2	6.1	43,824	.7620

SUMMARY

Mining Method.- The room-and-pillar method of mining, which has been the practice since the operations commenced, is rapidly being changed to the saw-toot and the long-face panel method which allows a greater concentration of the operations and substitutes mechanical loading for hand-loading. This method also introduces greater problems in roof control which are now passing the experimenta stage at these operations. The tonnage per man will be increased by the organization of crews to perform all the necessary operations of taking the coal from the face and loading it in the mine cars. At the present time crews consisting of from four to seven men load from 80 to 120 tons per shift.

Cutting.- The daily tonnage per mining machine for the year 1928 at the five operations was from 94.725 to 50.300 tons; while this may seem to be a low figure, it is due in part to the necessity of having to assign a machine to the development of one pair of entries or to a single face for the mechanical-loader operations.

Drilling and Blasting.- Drilling and blasting are part of the miner's duties and are paid for in the loading price. Electrical drills are used in the mechanical-loading sections for drilling, which is a good sign of progress in this direction. Five tons of coal were produced for each pound of explosive used in blasting, which shows that blasting has been given serious thought in these thin coal beds.

Loading.- At four of the five mines 22 mechanical-loading units were in operation during the year; and 23.45 per cent of the total output was loaded mechanically; for the individual mines the percentage was as follows: No. 2 mine, 21.5 per cent with four units; No. 3 mine, 18 per cent with six units; No. 4 mine, 24.39 per cent with eight units; and No. 5 mine, 66.16 per cent with four units. The latter operation is a small mine with an average daily tonnage for the year of 201.2 tons. These results show progress during what may be termed an experimental year for mechanical loading. In April, 1929, approximately 50 per cent of the output of these five mines was mechanically loaded. There is no doubt that in the near future with the present progressive officials in charge 100-per-cent mechanical loading will be the practice.

Timbering.- The table under the head of timbering shows that a total of 734,818 linear feet of timber for roof support was used to produce 930,215 tons of coal, or that 1.267 linear feet of timber was used for each ton of coal produced, or that 4.8 tons were produced for each post used.

The method of posting used for roof support is adequate for the requirements of the roof. No posts are recovered when making falls to assist roof control

Ventilation.- The ventilation of these mines does not present any unusual problem, because of easy access to the surface. When driving gateways for the various long-face methods, small blower fans are used to force the air to the faces

Transportation.- The transportation from several mine openings to a central preparation plant has necessitated some long outside haulageways which though expensive to install have been successfully introduced. The use of mechanical loaders is fast eliminating the gathering problem in underground haulage. The main haulage tracks are well built and maintained to allow efficient haulage.

Progress can be seen in the replacing of the 1 1/2-ton wooden mine cars with steel cars of 3 1/2 and 2 1/2 ton capacity equipped with brakes and Timken bearings; these cars will be a large factor in reducing transportation costs.

General Underground Conditions.- The general underground conditions are as good as may be expected when mining thin fairly clean beds of coal with a naturally good immediate roof, little water, and no gas. Open lights are used by all employees, and permissible explosives are used for about 50 per cent of the coal mined. No rock-dusting has been practiced. During 1928 an average of .7357 tons were produced per man hour worked, and 8.83 kilowatt-hours of power were consumed for each ton of coal produced.

Efficiency data for the five mining plants

Cutting machines, tons per average shift	77.762
Tons produced per pound of explosive	5
Tons per mechanical loader, four to seven men to each crew	80-120
Percentage of coal produced by mechanical loaders in four mines in use	23.45
Total tonnage mechanically loaded, 1928	173,365
Tons of coal produced per linear foot of timber used	1.26
Tons of coal produced per post used	4.8
Average daily tonnage per locomotive	110.24
Total kilowatt-hour power consumed	7,748,325
Kilowatt-hours consumed per ton of coal produced ...	8.33
Tons per man employed	5.988
Tons per man hour	.7485

* * * * * * *

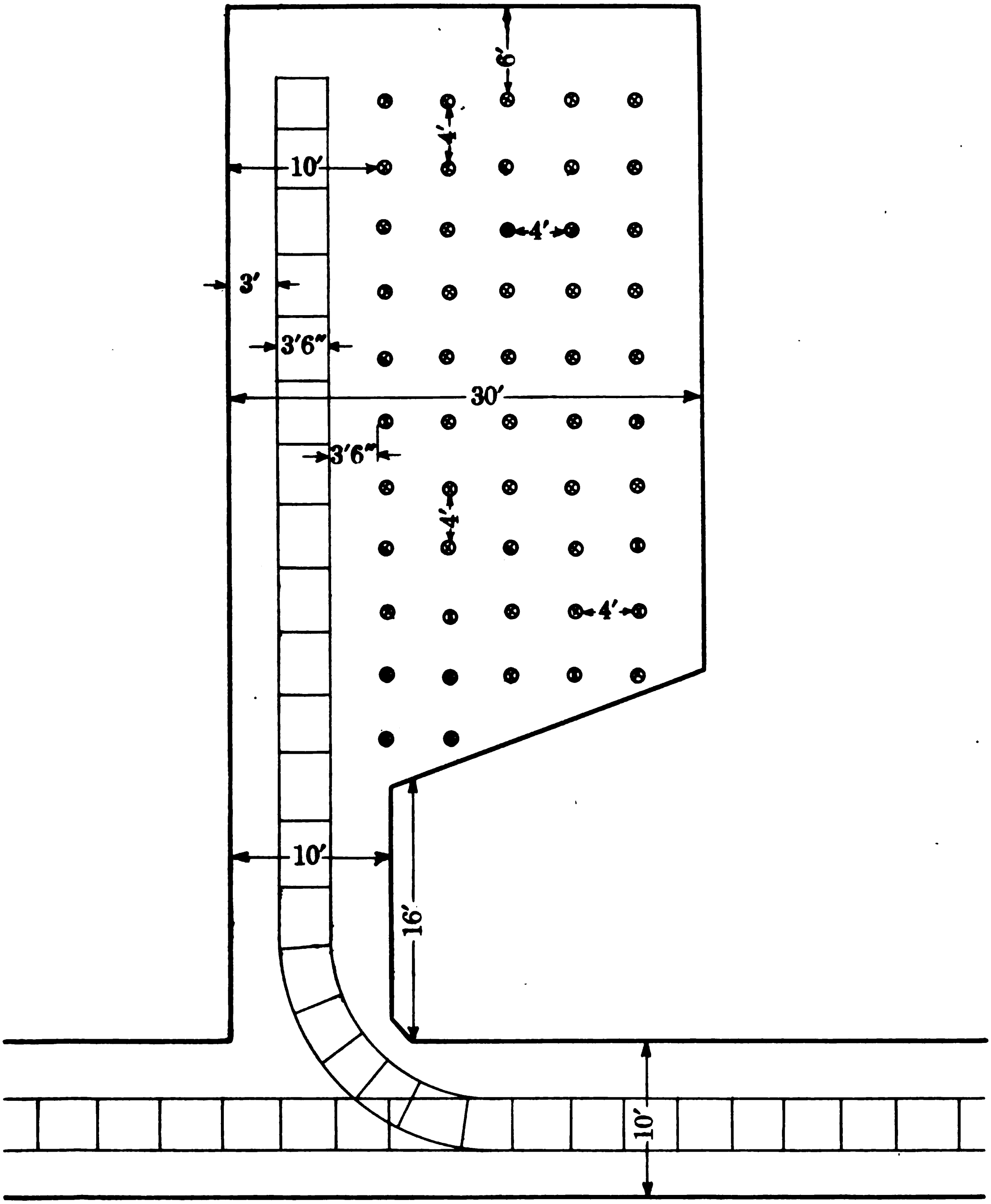

Figure 11.— Position of track and posts in a room 30 feet wide